Neo-classical economics and Technological change and the environmental policy

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ABSTRACT

Current mainstream micro-economics is almost entirely built on Neo-classical theories. Especially the existing environmental policy instruments have strongly replied on this approach. But it is just one economic approach and can not deal with all the environmental problems.

The study was focus on the point, which is investigating on the exiting neo-classical economics instruments and introducing the economics of technological changes and innovation, try to combine them into an integrated system.

Content

Preface

This study was conducted by Hao Zhang of 10th semester students from Development and Planning, Aalborg University. The period is from April 15th to September 16th.

The overall theme of the project is

Master Thesis

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Foreword

Personal Background & Motivation

I started my study in the field of Environmental Engineering since 1996 and it is almost 10 years. During the 10 years I was only worked as an engineer and I was thought environmental protection having nothing related to economics. But after the study at Environment Management in Alborg University, I came to realized that it is necessary to touch the field of economy and to learn how to use economics instruments cooperate with technical knowledge.

The motivation for this project is based on the need to study environmental economics and to investigate the existing economic policy system. After discuss with my supervisor *Frede Hvelplund*, I learned that there are some limitations within the mainstream economics—Neo-classical economics when it is used to deal with environmental problem. The study was focus on the point, which is investigating on the exiting Neo-classical economic instruments and introducing the economics of technological changes and innovation, try to find their shortcomings and advantages in order to combine them into an integrated system and to find the potential improvement from the combination of economics initiatives and technological demands.

Chapter 1 Background

Economic development and environmental protection are often viewed as conflicting objectives. The main thing connecting these two states is human economic activities.

"Environmental economics is the application of principles of economics to the study of how environmental resources are managed." (*Barry C. Field, 2001*) It is concerned with how economic institutions and polices can be changed to bring the environmental impacts into balance with human desires and the need of the ecosystem itself. Environmental economics play a major role to play in the design of public policies for the environmental improvement. Economic instruments are the tool with quite wide application in the field of environmental policy. With these instruments, financial burdens are put on the polluters so that the costs can motivate them to reduce pollution.

Environmental economic instruments are the tool to achieve environmental aims in addition to the continued predominant use of administrative regulations. The use of current economic instruments represents a tool for governments to promote the internalization of environmental costs and to apply the polluter-pays principle efficiently. They attempt to provide a method of enhancing the ability of authorities to deal with environmental and development issues. It was considered as a method to encourage sustainable development by charging a price for the use of an environmental resource. With these instruments, in some case financial burdens are put on the polluters. On the other hand, people are always thinking that environmental resources as free goods, but if the cost of environmental degradation were reflected in the price, people would integrate environmental concerns into their ordinary decision-making. This may be achieved by using economic instruments, such as emission charges, deposit and refund systems and tradeable emission permits. For instance, carbon market is an emerging market worldwide. The EU emission trading scheme as well as Kyoto Protocol creates a framework for carbon market and provides incentive for companies to reduce CO_2 emissions at minimum cost. (*Theodore Panayotou, 1994*)

From several decades ago, politicians which also including conservative groups have argued that the society needs to use rigorous economic analysis to evaluate the environmental problems, and that the best policies are those that rely on economic instruments. While legislation is aimed at directly changing the behavior of polluters by limiting certain practices, economic instruments aim to make environmentally damaging behavior cost more. Lots of environmental economics documents are dominated by the neo-classical economic theory and generally promote the "free" market as the best way of doing environmental protection. In the neo-classical theory environmental damage can be paid for or even preferable to avoiding the damage in the first place. Market solutions can make an advantage out of the profit motive and the pursuit of self-interest. These market solutions included fund or tradeable property or pollution rights or tax incentives and so on. These promotions of market-based instruments were introduced by many advocates as a way of resurrecting the role of the market in the face of environmental failure. *(Sharon Beder, 1996)*

Neo-classical assumption behind this economic instrument is that the environment can take a certain amount of pollution and that charges can ensure efficient allocation of that capacity to companies that need to utilize it. However, internalization of costs is a rhetorical argument, and environmentalists and others would counter that environmental quality is not something that can be exchanged for other products without a loss of welfare. This means that polluters are not paying the actual costs of the damage they cause. (*Daly, H. E, 1992*) argues that such adjustments to the market system are done to save face for economists and to avoid restructuring basic economic theory. Most of the methods used by Neo-classical economists do not consider the true value of the environment. They value the environment as a commodity market that can be assessed by finding out the people's willingness to pay in terms of preserve it. The market is a system that advantages those most able to pay, and volatile market prices can cause wasteful misallocation of resources. Many environmental values are not commodities that can be priced. So relying on a market system to protect the environment will inevitably disadvantage the poor. (*Sharon Beder, 1996)*

On the other hand, when dealing with economics of innovation and technological change are shown that it is possible to increases in the outputs without increases in the inputs. It can lower the cost through product innovations. (*Andreas Loeschel, 2002*)

said that Technological Change is not only a scientific theory, but also to an important key for economic development and environmental protection. Such as, higher energy efficiency of new products, and process innovations, or higher energy efficiency of manufacturing processes, cost reductions in low-emission energy conversion and improvements in fossil energy conversion.

Chapter 2 Problem formulation

In this chapter it will emphasize on problem formulation and to formulate the research question. Problem formulation is about explaining the problem and the reasons for choosing such a kind of problem.

2.1 Research question of this project

This analysis is intended to answer two research questions:

1. *How do the Neo-classical Economics influence the current environmental management policy instruments and what are the limitations of this approach?*
2. *Is it possible that a combination of Neo-classical and the Economics of innovation and technological change can transgress these limitations?*

Although many governments in this world are paying more attention to the development of new technology, but in fact most of they are still unwilling to change the decision-making structure that created the problems in the first place. "*The bureaucratic secrecy is still there and the unwillingness to put environmental protection ahead of economic concerns ensures that toxic waste will continue to be dumped in the sewers.*" (*Sharon Beder, 1990)* The overall project is based on the analysis of current Neo-classical environmental policy instruments and to identify their limitations and attempt to seek the potential improvements to the environmental policy instruments system by the integration of Neo-classical Economics and the Economics of innovation and technological change. The reason why these questions were chosen will be explain in the following section.

2.2 Why the above-mentioned problem?

First of all, as we known, present-day mainstream economics theory is almost only based on neo-classical theories. This theory paint the basic framework of analysis used nowadays in most economic models and research. As its consequence, the current environmental economics instruments are mainly build on this theory. But many economists argued that it is questionable whether this theory is suitable for this society. For instance, the Nobel Prize winner, Douglass North has written in 2004 that *"Neoclassical economics fails to explain how countries can achieve economic growth because it was designed to talk about how well-developed markets work, but many countries have a fundamental problem in that their markets are not well-developed." (Douglass North, 2004)* And he also claimed that "*Neoclassical theory is simply an inappropriate tool to analyze and prescribe policies that will induce development. It is concerned with the operation of markets, not with how markets develop…. " (Douglass North, 1994)* So that in order to find out why the Neo-classical economics fails and why this theory is an inappropriate tool according to North's opinion, I have such a research question as: **How do the Neo-classical Economics influence the current environmental management policy instruments and what are the limitations of this approach?**

Secondly, Neo-classical analysis can be considered as describing only a part of economics. Regarding the current environmental problems, there is little doubt about the Economics of innovation and technological change has the potential to substantially contribute to new solutions for environmental instrument since technology has helped to significantly increase efficiency, such as in energy use in the past. Although Neo-classical Economics play a main role in existing economic theory, the research area of the economics of innovation and technological change has flourished over the past decades. The Economics of innovation and technological change has become a research area in which a mix of mainstream methodology and alternative approaches co-exists and co-evolves. But it is still not unanimous that the Economics of innovation and technological change is powerful enough to solve current and future environmental problems. Like *(Pearce D., 2002)* said that technical progress plays a much less prominent role than in Neo-classical contributions in the

current policy system. On the other hand, when simply looking at the relationship between policy instruments and economic performance, L. Wei found that the effects vary depending on the predominant institutional conditions (*L. Wei, 1998)*. As *Frede Hvelplund* has pointed out in the 7th semester's lectures that there are many institutional conditions such as research, education, test station etc. etc. which is behind the economic development and affects the policy constitution. **Figure 2.1** shows that a successful economics development should have various institutional conditions to support. The existing Neo-classical economic instruments are not suitable for the technological changes and for the environmental development. The best way from the political point of view to promote the economic development and environmental protection is to combine the instruments both from the Neo-classical Economics and the Economics of innovation and technological change. So that another research question has come into being as: **Is it possible that a combination of Neo-classical and the Economics of innovation and technological change can transgress these limitations?**

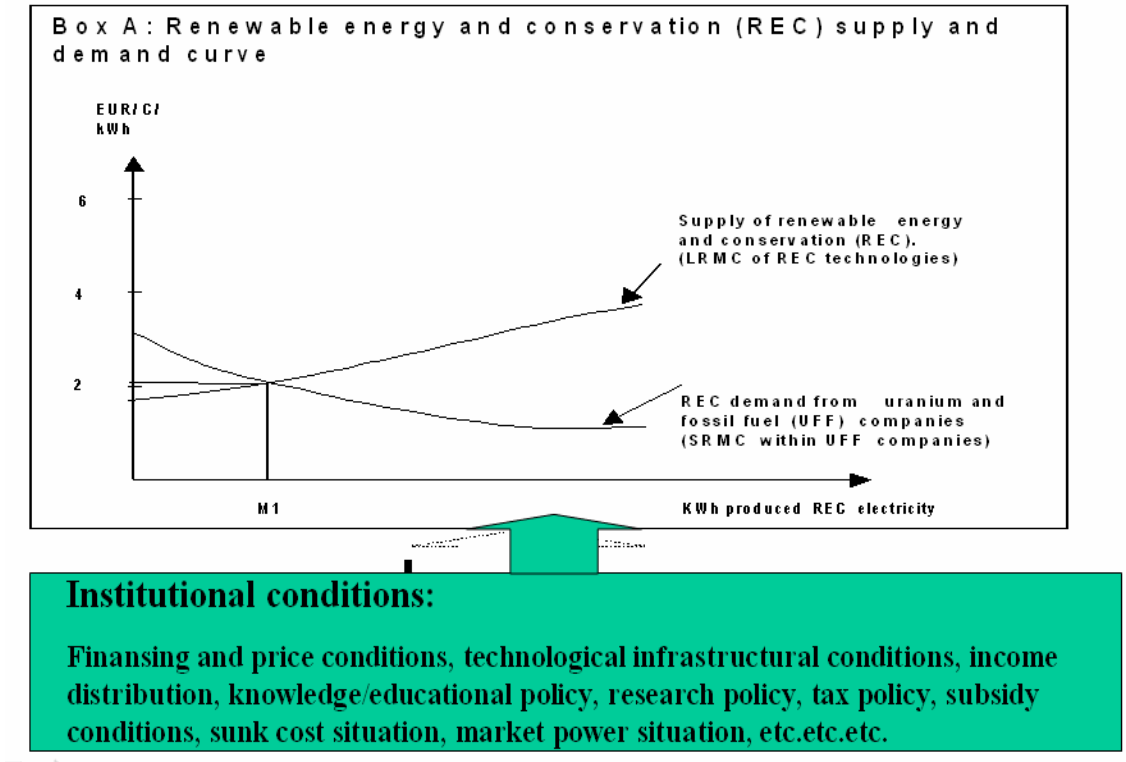

Figure 2.1 Renewable energy supply and demand thinking. (*Frede Hvelplund, 2003*)

As we seen from **Figure 2.1**, box A can express the renewable energy supply and

demand by the simple and linear coordinate. It is a typical Neo-classical curve but under this curve (Box A) there are several institutional conditions which influencing the economic development which neoclassical economics theories do not concerned. Based on this **Figure 2.1**, we can figure out the premise for a successful economics performance is depending on these two effective demands:

1. It may be attributed to a so-called market-based economy, namely Neo-classical Economic instruments. It is a problem for short-term imbalance of the market mechanism. This can be tackled by formulating fiscal instruments (such as Taxes, subsides and so on) to make up for the inadequacies in market mechanisms and clearing obstacles to the economic performance so as to restore the balanced economic growth.
2. It can be attributed to institutional conditions such as causes of technological change. These institutional conditions are supporting the innovation and new technological operations, meanwhile in a long-term view it helps the companies to reduce the cost (such as payment to environmental taxes and charges) in order to make the optimal point. The institutional conditions help market-based policy instruments to maintain and stabilize economic growth from adapting to the demands of a market framework.

Above all, in order to find the potential improvements to the environmental policy instruments, the analysis has to be based on:

1) Go through the current policy instruments which is Neo-classical instruments, and find out the advantage and the limitations,

2) Investigating on the Economics of innovation and technological change, find out the possibility to integrate its advantage with the Neo-classical economic and to find out the potential approach of economics improvements.

Chapter 3 Research methodology

This chapter describes and explains the methodology deployed in this study in order to introduce the basic idea of this report.

3.1 Design

One of the greatest challenges facing this project was to design a research methodology. The idea of this report was going to integrate the existing Neo-classical policy instruments, to form a better tool to manage environment. Therefore, this report has decided to focus on the point, which is going to investigating on the existing Neo-classical economic instruments and introducing the economics of technological changes and innovation, try to combine them into an integrated system and to find the potential improvements to the policy system.

The research methodology adopted in this research consists of the following steps:

1. Investigate through literatures of Neo-classical Economics and the Economics of innovation and technological change, the current applications of environmental policy instruments.
2. Better understand the specific problem under study by collecting data and information about the various elements contributing to environmental instruments.
3. Develop a conceptual design of the integrated model, namely integrated policy instruments of Neo-classical Economics and the Economics of innovation and technological change, followed by three examples in order to represent the various system components:
    a) Tax reform (cause from the limitations of current taxes and charges system),
    b) R&D (cause from the limitations of current subsides system)
    c) Innovative market (one of the existing examples about the combination of Neo-classical economics and the economics of innovation and technological change)

In addition, the research is multidisciplinary and is being analyzed across economy and technology. The objectives were further refined as a set of research hypotheses and this has proved extremely valuable in providing an integrating framework for the project.

3.2 Data collection and Limitations

The common methods of data collection should involve interview, observation and the analysis of documents. But this report only has a qualitative method, which is review of published and unpublished literature and documentation.

The literature review was performed to better understand how environmental economic instruments work and what kind of instruments need improved by the economics of innovation and technological change. It need to overview the background information about the project and the relevant readings and documents about the issues, which need to be investigated. The study is theoretical sampling and I have to collect record, code and analyses data and constantly decide what data is to be collected next and where it should be collected. There are many related readings and many opinions which come from different schools of economics thought, and it was hard to distinguish which one is useful and who has the right suggestions. The only way to solve this problem is to gather literature information through reading on theory, research and documents (books, articles, mini-dissertations) of various kinds and to identify the useful one according to the research question. Through literature review, I identified key issues from the perspectives of current environmental economics instruments, and I finalized research questions related to the project objectives. The analysis of this report based on 56 literatures which is shown in the list of references. For it is not possible to introduce them one by one, I am going to illustrate some of the literatures that is relevant to the subject. It is divided into four major sections including the following:

Neo-classical economics and policy instruments:

There so many relevant literatures in this field since most of environmental economists refer to describe the Neo-classical economic model. My most previous

studies have focused on this field. This report has been investigated on several books and articles for example: Barry C. Field, 2001: *Environmental Economics - An Introduction.* His book introduced me what is environmental economics and why should we have to learn this concept. It was the first book that I read about a subfield of economics concerned with environmental issues. After read this book, I came to realize the fact that the current environmental policies are mainly based on the structure of Neo-classical Economics. Other books like J.B.Opschoor, 1989: *Economic Instruments for Environmental Protection* also helps me to know what the economic instruments for environmental management are and how people implement these instruments.

Criticism of Neo-classical economics:

In terms of find out what are the limitations of the Neo-classical economics, I also read some articles which was talking about the criticism of the Neo-classical theory. For instance, Sharon Beder, 1996: *Charging the Earth: The Promotion of Price-Based Measures for Pollution Control.* Sharon Beder is one of scholar who is against Neo-classical economics. And this paper examines the rationale for price-based instruments and tells me what the limitations are.

Economics of innovation and technological change in environmental sector:

The method of data collection was collected from different literature. This book, Frede Hvelplund and Henrik Land, 1998: *Feasibility Studies and Public Regulation in a Market Economy* as the major reference gives me a very detailed description about the relationship between the present, social and institutional economics. It is also gives me a very clear picture about technological change and innovation. It helps me to understand the situation, where technological and institutional changes are requisite. And the second research question was come from the studying of this text book. Also there are many other articles are very good at expressing the innovation and technological change issues such as Andreas Loeschel, 2002. *Technological change in economic models of environmental policy: A survey.*

Examples of integrated instruments:

Danyel Reiche, 2005: *Handbook of Renewable Energies in the European Union* described the current renewable energy situations in the EU countries and exhibited

particular standards and examples of each countries. It was a great help to me that I can investigate the existing environmental instruments and the policies tendencies for the energy section. And from this book, I quoted the example of innovative market for support the integrated instruments.

Apparently, there are many books which worth to read and could be very useful for this report, but due to several reasons, I can not go through with them all. And like other research reports, this report still has the following limitations.

1. This study is a full self-study and I did use different data from different literatures to observe. However, I am aware of the limitations of my methodology since there are always other stories within a story which have not been explored.
2. First-time experience within the new study field cannot be captured very well. First-time experience is incomplete. To learn to change and to generate new knowledge from a technical engineer to an economic student is to experience change.

3.3 Diagrammatic presentation of approach

The project consists have three major activities:

1. Studying current Neo-classical economic instruments and identifying the short comings and advantages.
2. Studying on the economics of innovation and technological change and identifying its advantages and shortcomings.
3. Developing an Integrated instrument system which incorporates established Neo-classical economic instruments and key elements of the economics of technological changes and innovation to solve the short comings.

The stepwise approach is expressed schematically as the **Figure 3.1**.

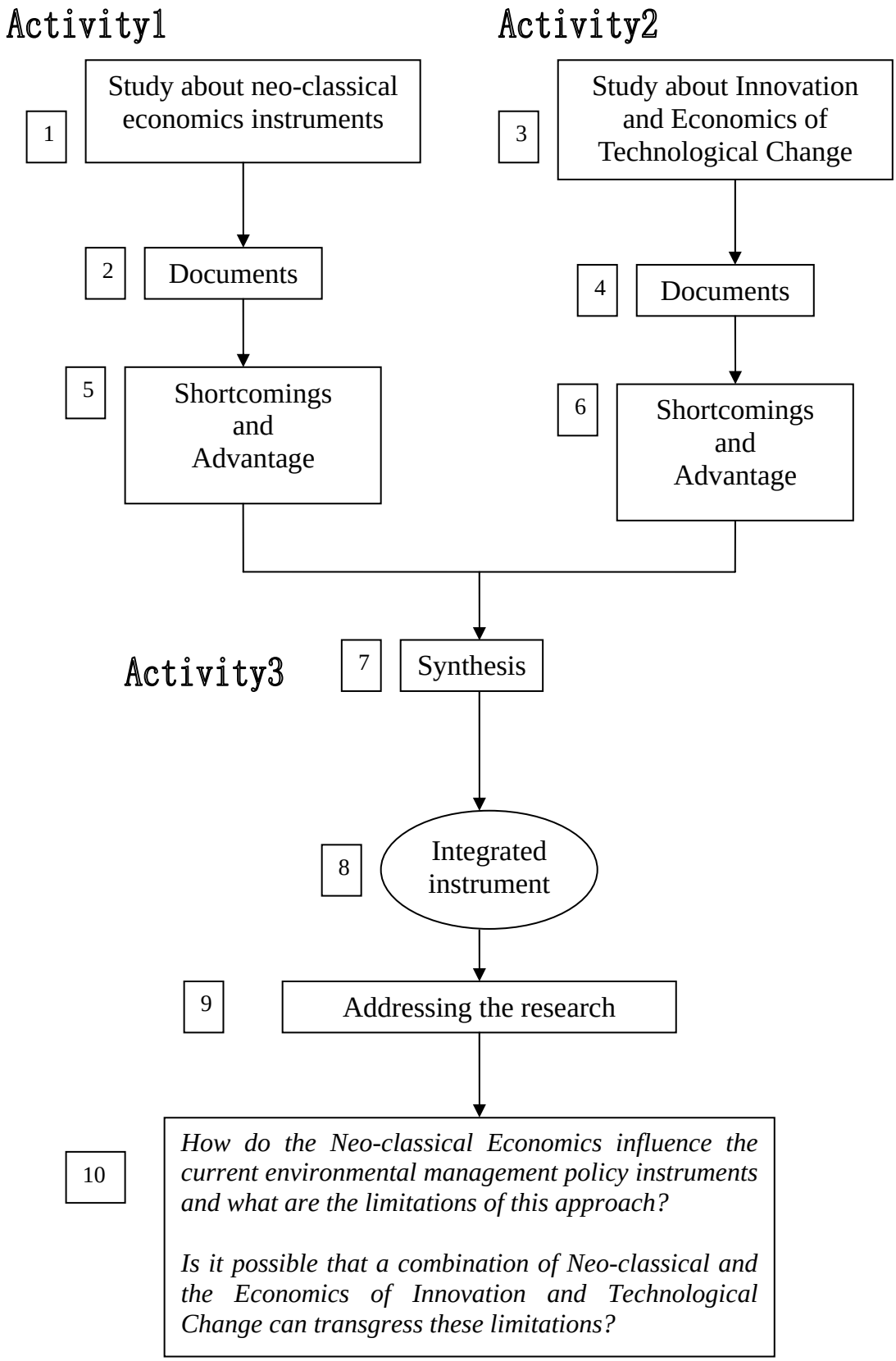

Figure 3.1 Diagrammatic presentation of approach

For the regard to answer the research question, the following chapters are introducing here:

- **Chapter 4** will introduce the relationship between the Neo-classical economics and environmental protection and how is the Neo-classical economics used in environmental management. It will concern of step 1 and step 2 according the diagram.
- **Chapter 5** will present the Economics of innovation and technological change in environmental sector and describe the methodology and advantages of implementing Innovation and Technological Change. It will concern of step 3 and step 4 from the diagram.
- **Chapter 6** will focus on the evaluation of the Neo-classical economic instruments and Innovation and Technological Change. The current criticisms for the environmental instruments such as taxes, charge and subsides will be repersented. It will concern of Step 5 and step 6 according to the diagram.
- **Chapter 7** will introduce the synthesis of the Neo-classical and Innovation and Technological Change Economics. It will combine the advantage of the Economics of innovation and technological change with the shortcoming of Neo-classical Economics followed by suggestions for three examples (Tax reform, D&D and innovative market). It is reflecting on the step 7 and step 8 from the diagram.
- **Chapter 8** will conclude this research and give some recommendations which could reflect on the step 9 to step 10.

Chapter 4 Neo-classical economics and Neo-classical economic instruments

The purpose of this chapter is to provide an introduction to Neo-classical economics and the relationship between the Neo-classical economics and environmental management. A description of Neo-classical economic instruments in the environmental aspect is presented in this chapter to interpret how Neo-classical economic is used in environmental management?

4.1 Neo-classical economics

Present-day mainstream micro-economics is almost entirely built on Neo-classical theories of consumer and producer behavior. Especially when most of environmental economists in this world refer to the views and main foci of the environmental economics, they tend to describe the Neo-classical economic model. Indeed, the Neo-classical economic approach probably remains as the dominant influence in mainstream environmental economic thought today. Neo-classical economics is emerged in the late 19th century when the so-called "marginalist school" introduced the concept of market equilibrium conventionally dated from William Stanley Jevons's Theory of Political Economy (1871), Carl Menger's Principles of Economics (1871), and Leon Walras's Elements of Pure Economics (1874 – 1877). (*Wikipedia, 2005*)

William Stanley Jevons, 1835 -1882 (*Newschool, 2005*)

Neo-classical economists define economics as the study of "*the allocation of scarce resources among alternative ends*". (*Wikipedia, 2005*) It focuses on the exchange of goods and services among the economic agents. Neo-classical economics is focusing economic phenomena to study by similar methods to those of natural science. It uses mathematics and statistics since many economic variables are seen as quantifiable. It begins with the premise that resources are scarce and that it is necessary to choose between competing alternatives. It represents a marked shift in focus to the motives

and behavior of the individual rather than social institutions. There is an assumption that individuals are the best judges and agents for actions. The market system was seeing as fundamentally self-regulating. Price is set and demand determines the quantity of emissions that are released. Prices adjust to accommodate any changes in supply and demand conditions and remove any potential conflict associated with these changes. In fact, the assumption in internalizing the costs is that environmental damage can be paid for. A further assumption behind the theory that there is a point of optimal damage is that increasing pollution reduction is increasingly expensive for smaller and smaller environmental gain. *(Peter L. Daniels, 2001)*

Neo-classical theories often revolve around utility and profit maximization. This theory define producers, who focus on maximizing profits, reach a balance situation that the marginal cost [1]of their production equals the market price of the product; Consumers aim at maximizing utility, reach a balance when the ratio of marginal utility (the additional utility of an extra unit of a good) of any pair of goods in their consumer basket equals the ratio of the corresponding market prices. (*Bertin Martens, 1995*)

Neo-classical economics emphasizes equilibriums, where equilibriums are the solutions of individual maximization problems. This equilibrium theory was fast becoming the recommended policy reference for all over the world. This theory was defined can always create an efficient allocation of society's resources. As a result, many politicians advocate rolling back regulations in order to let the market protect the environment. Economic efficiency can only be reached in perfect competition when P = MC (first optimal solution) and only then markets are seen as superior. Neo-classical economists argue that the market is better able to find the optimal level of environmental damage, the one that is most economically efficient. This optimal level of damage can not be zero. The optimal level of pollution is the level at which the costs for cleaning up equal the cost by the environmental damage so that the company will clean up its pollution until any further incremental reduction in pollution would cost more than the remaining charge until it is cheaper to pay the

[1] Marginal cost is defined as $MC=\Delta C/\Delta Q$, ΔC stands for the change in output and ΔQ stands for the change in cost. As usual, marginal cost can be interpreted as the additional cost of producing just one more ("marginal") unit of output.

charge than reduce the pollution. This is said to be economically efficient because if the polluter spends any more than this the costs of extra pollution control will outweigh the benefits. It can be indicated as **Figure 4.1**.

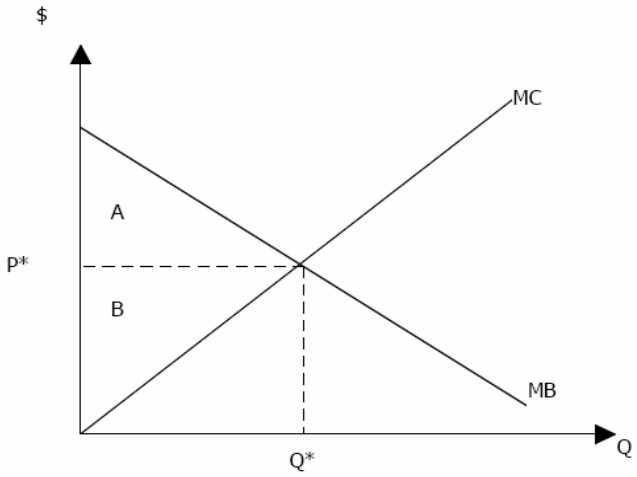

Figure 4.1 Market Equilibrium (*Walter Block, 2002*)

As a typically standard, the basic model is that in equilibrium "P*=MB=MC=ATC".[2] This is represented to be the typically standard as the following reasons: (*Walter Block, 2002*)

1. As P measures the marginal social benefit and MC, P*= MC insures that Q* is the socially optimum quantity; additional units of output will be produced and sold so long as the additional benefits thereof exceed the additional costs, and no unit will be produced if the cost exceeds its benefits.
2. As MB measures the benefits to the producer (the private benefits), MB= MC insures that Q* is the privately optimum quantity.
3. MC= ATC insures Q* is the optimum quantity in the sense that no other level of output could be produced at a lower per unit cost.
4. P*= ATC insures that normal profits are earned. There are no above normal profits to induce existing producers to increase the level of production or induce others to enter the market, nor are there below-normal profits to induce existing producers to decrease the level of production or to exit the market; therefore the market is in equilibrium when operating at this optimal level of output, Q*.
5. P*= MB ensures that the marginal social benefit (P*) and the marginal private

[2] Q is quantity, P is the price, MB is the marginal benefit, MC is marginal cost and ATC is the average total cost.

benefit (MB) are the same, and therefore there is no divergence between the condition for social optimality (P* = MC) and that for private optimality (MB= MC).

Because Neo-classical economics is still so influential, it is important for us review some of the main characteristics and the way that the environment instrument is perceived under this school of thought. Therefore to make a better understanding how the Neo-classical suggestion works, I am going to illustrate them with the existing common policy--fiscal instruments such as taxes and subsidies in the following part.

4.2 Examples of Economics instruments: Taxes and Charges, Subsides

Economics instruments were the key to the integration of environmental considerations into other policy area and it was the key to a sustainable development. Regulatory instruments can be described as "*institutional measures aimed at directly influencing the environmental performance of polluters by regulating processes or products used, by abandoning or limiting the discharge of certain pollutants, or by restricting activities to certain times, area and so on, trough licensing, setting of standards etc*". (*J.B.Opschoor, 1989*)

The actual mixture of instruments used in environmental policy varies from country to country. The current economic mechanism for environmental protection has being formed during many years. The actual development of environmental policy in the European Union over the past, are very much in depend with the advice of Neo-classical economics. Neo-classical economist thought economics instruments rely on market price mechanism to internalize costs and provide financial incentives to economic actors. These price-based instruments are considered as a price to be paid for pollution. (*Sharon Beder, 1996*)

The existing economics instruments can be classified in a number of ways. This part will not try to account for every instrument, but rather to provide a general survey of the more representative contributions of a given idea of Neo-classical economic instruments on the environmental section. It will identify two crucial attributes of Neo-classical economic instruments that have been stressed in the more substantive modeling effects. Basically, this report discusses the following fiscal instruments by the Neo-classical economics: Environmentally related taxes and charge systems and Environmentally Motivated Subsidies. Within the two broad strands it will look more closely at the most influential works of the Neo-classical economic instruments:

4.2.1 Environmentally related taxes and charge systems

Neo-classical economic instruments have been applied as tools to achieve environmental aims in addition to the continued principal use of administrative regulations. The use of Neo-classical economic instruments for environmental policy making has been developed extensively in recent years. For instance, it was reported that the total revenue from pollution charges and environmental taxes has increased by about 500% in current prices since 1995 in Estonia. It is appeared that the tendency of using taxes and charges has increased distinctly. (*United Nations Economic Commission for Europe, 2001*)

The most common Neo-classical economic instruments employed are various taxes and charges. Environmental taxes and charges can be a way of implementing the "polluter pays" principle by inducing consumers and producers to adopt more environmentally compatible behavior. It is used to ensure that private companies pay the costs of the environmental damage that they cause and it is supposed to provide an incentive for them to reduce that damage. The EU Commission defines taxes and charges as "*covering all compulsory unrequited payments whether the revenue accrues directly to the Government budget or is destined for particular purposes*" (e.g. earmarking). (*The EU Commission, 2005*)

Taxes:

Taxes are one of the oldest forms of pollution control. It is unrequited in the sense that benefits provided by government to taxpayers are not normally in proportion to their payments. It is the financial instruments for the distribution of wealth in the society and can be used effectively with other instruments to create a balanced policy package which takes account of economic as well as environmental objectives. The OECD defines environmentally related taxes as any "*compulsory*, unrequited *payment to general government levied on tax-bases deemed to be of particular environmental relevance*". Environmental taxes have many different types, but as general, environmental tax measures either impose a tax cost on some products or activities that is environmentally damaging, or they give a tax benefit to some products or activities that is environmentally beneficial. OECD reports that the goal of the

environmental taxes is to make pollution and depletion of resources more expensive therefore to provide incentives for environmental protection. An effective environmental tax policy shifts the tax burden from the general population to the polluter, and changes the behavior of a society. With an emission tax, the polluting plant would reduce the emissions until the costs of further pollution reduction equal the tax. It will be useful for both pollution control and the management of a natural source. (*OECD, 2005*)

So how does Neo-classical economist define an efficient emission tax? It will show as **Figure 4.2.**

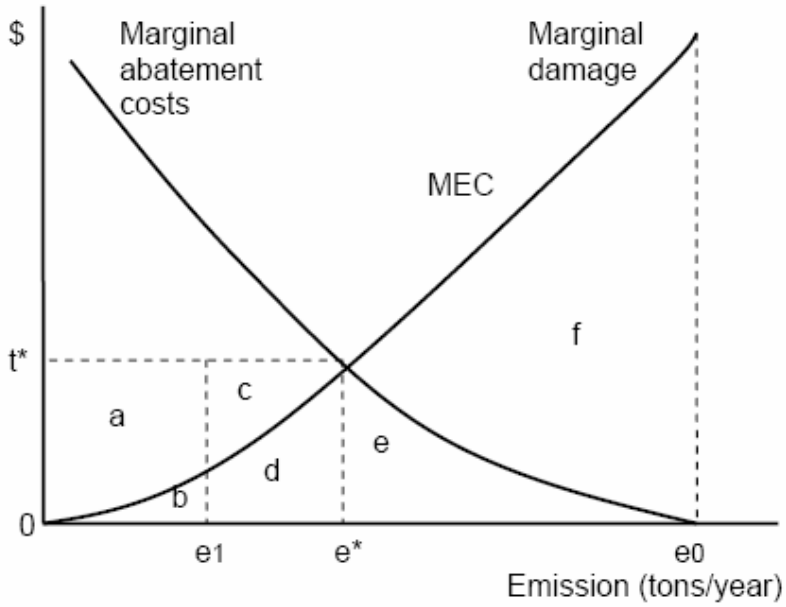

Figure 4.2 Efficient emission tax. (*Sebastian Storfner, 2004*)

Figure 3.4 shows that at t*(tax) match e*(emission), and the marginal damage equals marginal abatement costs. Total costs for polluters are abatement costs and tax payments (a + b + c +d). Therefore, the reduction of emission from e0 to e* has eliminated damages of (e + f), while the remaining damages (b + d) are less than the polluters pay taxes. By raising the price of polluting to reflect social cost, environmental taxes ensure that polluters face both the private and the social costs of their actions. But in the absence of taxes or other control instruments, environmental damaging activities tend to be carried to excess. More discussions about the weakness of tax are going to carry on in the **Chapter 5**.

In addition, the Nordic countries have become the representative couriers in the use of economics instruments. They have imposed carbon dioxide taxes and a number of other tax mechanisms to protect the environment. These taxes for example directed towards fossil fuels can be divided into a basic energy tax, a tax on carbon dioxide and a sulphur tax. But each country has its own specific environmental tax system. Such as Sweden and Denmark apply taxes on nitrogen in fertilizers and almost all countries tax pesticides. Finland applies a differentiated tax on cargo vessels, and Denmark has introduced a tax system with the aim of reducing the discharge of waste products from municipal and industrial treatment plants. Waste disposal taxes are levied on waste supplied to landfills and incinerators in the majority of countries (See **Appendix 1).** (*European Environment Agency, 2000*)

Charges:

The most common form of price-based measure is a charge. Neo-classical economist devised there are four types of charges, including (*J.B.Opschoor, 1989*)**:**

1. **Effluent charges** are charges to be paid on discharges into the environment and are based on the quantity or quality of discharged polluters. It used mainly in the area of water pollution control and are based on the content and quantity of the waste stream.
2. **User charges** are fees charged for using a resource or for being provided with a service, it is payments for the costs of collective or public treatment of effluents.
3. **Administrative charge** is fees for authority services such as registration of chemicals or implementation and enforcement of regulation.
4. **Product charges** are charges laid upon the price of products: they are used to discourage disposal or encourage recycling.

Most Neo-classical economists claimed that the use of charges in environmental policy will have substantial efficiency advantages due to such two phenomena.

- Environmental assets such as forest, marine production or minerals, were bought and sold to the market but the price does not present the true cost of obtaining them since the damage to the environment has not been included. Other environmental resources such as air are not given a price. Economists argue that environmental assets tend to be overused or abused because they are too cheap.

So that it is necessary to charge in order to protect the environment. (*Sharon Beder, 1996*)

- Charges may also be considered as a price to be paid for pollution. For example a company that has to pay a charge to discharge waste into a river may work out that it can save money by treating its before putting them in the river. If it decides not to do this then it has to pay the full charge. Charges are rather based on actual emission levels than on allowable levels which give companies a clear incentive to lower emissions more than the allowable levels. In this way the cost of the pollution is incorporated into the price of its products. On the other hand, consumers then have the choice to pay the extra. Alternatively they can buy a different product that is cheaper because it causes less environmental damage. Neo-classical economists thought that external costs and benefits (externalities) that are not taken account of in market activities and the companies have to pay for the external cost since it causing environmental problems. Price-based instruments, such as taxes and charges, are supposed to make external costs part of the polluter's decision. (*Vincent and Farrow 1997*)

4.2.2 Environmentally Motivated Subsidies

To defense the market failure, the use of Neo-classical economic instruments, such as subsidies, has increased in recent years. A subsidy is to keep prices below the market prices by giving financial support to producers for their production. Subsidy is a general term for various forms of financial assistance which acts as an incentive for polluters to change their behavior. It intended for environmental purposes of giving incentives for more environmentally friendly actions. Denmark has define subside as *"in order to be an environmental subsidy, it has to reduce the use of one or more physical units that have a proven specific negative impact on the environment*". (*Statistiska, 2003*)

Environmental subsidies can be seeing as unrequited payments to producers from government. Neo-classical economists consider that a subsidy is introduced to change the marginal cost of a product and can therefore change the price of a product or service. Producers are willing to accept a price lower than the actual cost of production because the subsidy makes up the difference. Subside are financed in several ways. For example, charges are the main source and revenues from user charges and administrative charge are used for financing collectively maintained control facilities and for government services. The general budget is the second source of financial assistance. A third source of subsides is revolving funds. (*J.B.Opschoor, 1989*)

Neo-classical economists consider the optimal environmental subsidy is also equal to the marginal environmental damage at the level of the optimal tax. There are three types of subsides such as grants (non-repayable), soft loans (the interests rate are set below the market rate) and tax allowances (allowing accelerated depreciation or other forms of tax or charge exemptions). Subsidies are given in the form of soft loans to polluters facing strict environmental standards are being held fully accountable for their environmental costs. Subsidy giver is the government or another public entity, subsidy recipient are almost typically private and profit-oriented companies. Subsidies in many countries are depending on Neo-classical economic theory which to separate selective subsidies from other forms of state intervention. For example, support to non-profit organizations and parts of the public sector are considered subsidies,

whenever they produce or provide private goods, but public supply of these goods and services is not necessary for economic reasons. (*Boss, A. 2002*)

Chapter 5 Economics of innovation and technological change in environmental sector

This chapter presents the conception of the economics of innovation and technological change. It will emphasize on the R&D aspect and current policy tendencies and prospects.

5.1 Introduction

The economics of innovation and technological change is fundamental for rendering the energy economy cleaner and more efficient with concomitant economic, developmental, and environmental benefits.

As *Frede Hvelplund* pointed out that technological changes may consisting of plenty elements during its implementing and also it has different technological categories when faced to the old technologies. "*The technological change can be seen as a change from undifferentiated solutions implemented by few single-purpose organizations to differentiated solutions implemented by many multipurpose organizations*". *(Frede Hvelplund and Henrik Land, 1998)*

Technological change can shift the relative production advantages among communities, for example less of a local resource being needed or other local resources becoming more productive. In many countries, technologies have allowed to significantly improve the environment. For instance, in western countries, local air and water qualities are better than they used to be some years ago. Technology has also remarkably helped to increase efficiency in energy use. Innovation is normally taken to include all stages of new economic activity including the "*search for and discovery, experimentation, development, imitation and adoption of new products, new processes and new organizational set-ups*" (*Dosi, Giovanni, 1988*). Innovations may be either radical, which involve discontinuous change and the introduction of new technologies, or incremental, which involve gradual improvement of existing technologies and techniques. (*Joseph Murphy, 1999*)

Innovation and technological change not only can play a substantial part in environmental management, but also play a very important role in the economic development. As (*Paul Hawken, 1999)* point out technologies available today can save around twice electricity than five years ago, at only a third the real cost. In the short run it can appear to be serious conflicts between economic activity and environmental quality. Over the long run, the cumulative effect of technological innovation can greatly improve. Technological change and innovation commonly can be distinguished as incremental and radical innovations. Incremental involve gradual improvement of existing technologies and techniques, used to underpin the cumulative and adaptive character of technological change with emphasizing learning effects connected with routine activities and modifications upon existing technologies and knowledge. Radical involved discontinuous change and the introduction of new technologies and techniques, is point to the intrusion of new things that fundamentally alters the way in which technologies are perceived. Although the incremental and radical imply differences regarding the extent of change, they all play an important role with respect to economic and technological progress. (*Jaffee and Stavins, 1995*)

Innovation and Technological Change are very important for it can reduce the cost for the companies and it is possible to avoid the damage in the first place. This premise is based on the idea that pollution reduction is achieved by pollution control equipment being added to production processes, whereas the aim of clean production processes is to change production processes so that the pollution is not generated. These changes in production processes may in fact end up saving firm money over the long term.

Recently, all the methods of neo-classical economics, and its environmental branch have difficulties when dealing with new and complex problems. For instance, the neo-classical "Solow-model" said that economic output is a function of available capital and labor stocks. Investments increase the capital stock and production capacity. But empirical tests of this model, by lots of economists, showed that the explanation of economic growth was limited and an unexplained growth residual remained (*"Solow-residual"*[3]) that could only be explained in terms of productivity growth. This weakness of the model can be remedied by the introduction of

[3] Solow residual is a measure of the change in total factor productivity in a Solow growth model. This is a way of doing growth accounting empirically either for an industry or more commonly for a macro-economy. (*economic).*

technological change that increases the productivity of capital and labor, and thus increases output while input levels remain constant. Investments in new equipment can be more productive because of technologies improved. Labor productivity also increases since the knowledge and education levels and skills are increase in the labor force. And this solution is mainly based on the construction of the four circles of Technological Change which can be shown as following **Figure 5.1**.

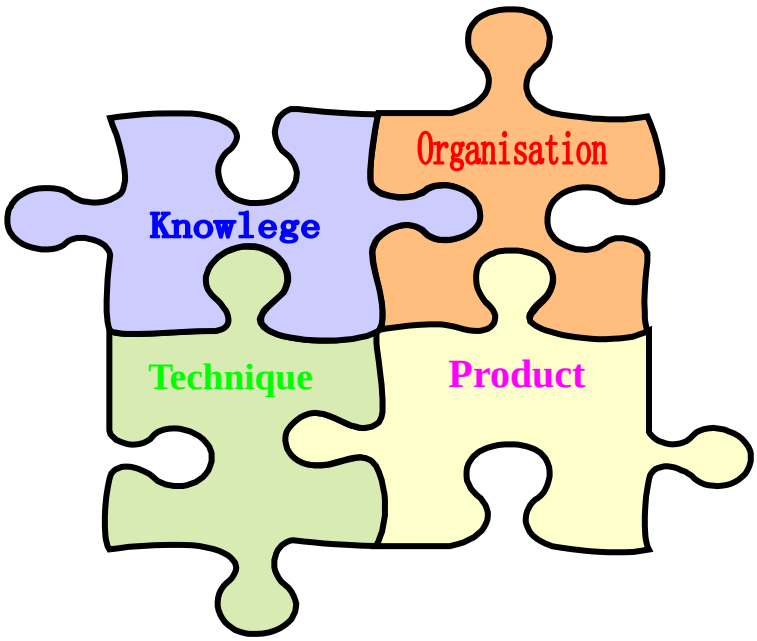

Figure 5.1 Four circles (*Jens Muller, 2001*)

Figure 5.1 shows technology is now seen as having four inter-related constituents: technique, knowledge, organization and product. They are interacting on each other. If the technique improved, knowledge has to increase in order to reach the same level. Products are changed for it is a new product which covering a high technology. Organization is changed in term of to fit the new technique. As new technologies and products were developed, older ones who held the patents on the old technologies has been replaced or destroyed as consequence. In addition, if the new technology is radical enough early adopters can exert strong monopoly powers and force later adopters from the market. The important point is the idea that new technology and innovation induces people to start or operate new companies. This causes a dynamic sense of disequilibrium in that many things, in both input and product markets, and production processes are changing at the same time. As we saw in the neoclassical model shifts in technology and the introduction of innovations cause the growth path

of the economy to shift resulting in short term disequilibrium. (*Jens Muller, 2001*) (More discussion on this figure will carry on in the **Chapter 7.1** tax reform related to the second research question**)**.

Government policies designed to address technology transfer must work or be aimed at the organization level. Technology transfer requires transfer of knowledge across disciplines, professions, industry sectors, regions, and communities. Thus, it is an organizational and cultural process as well as a knowledge transfer process. The government has a role in supporting basic research. Another key element as technology becomes more important to the economy is the ability of the labor force to take advantage of and used technologies and innovations. This translates into the increasing role of educational opportunities beginning primarily education, institutions of higher education, and continuous retraining opportunities.

5.2 Example of Innovation and Technological Change: Research and Development

Due to there are so many aspect can be illustrate to represent the economics of innovation and technological change, I am going to pick up one of the famous contributors Research and Development. (R&D) And also because the invention and innovation stages are carried out primarily in private firms through a process that is broadly characterized as “research and development” (R&D).

There is a measure of the inputs into the innovative process, such as R&D expenditures, or else the share of the labor force accounted for by employees involved in R&D activities. R&D is the practical application of scientific and engineering knowledge for improving technology, management techniques and social activities. R&D is systematic investigation carried out in the natural and engineering sciences by means of experiment or analysis to achieve a scientific or technological advance. **Research** is original investigation undertaken on a systematic basis to gain new knowledge. **Development** is the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes. The institutionalization of R&D has been one of the most central changes in the way in which companies compete and change their technologies. R&D mostly starts at the first stage of technical development, preceding the commercial use of a new technology. In recent years, there has been much concern about trends in R&D budgets, especially in the context of the challenges posed by climate change, since addressing these almost certainly requires significant innovation in the energy sector. (*Zoltan J. Acs and David B. Audretsch, 2005*)

It is clear that many environmental problems need new technologies to get rid of the pollution discharge. For many environmental problems, technological innovations can offer fundamental solutions. Environmental R&D is the R&D with the goal of reducing emissions to protect the environment.

Chapter 6 Evaluation of Neo-classical economic instruments and Economics of innovation and technological change

This chapter presents an evaluation to the current Neo-classical economic and analyses the currently applied Neo-classical economic instruments in order to gain a general understanding of the issues related to environmental development.

6.1 Evaluation of Neo-classical economics and instruments

6.1.1 Neo-classical economics

The Neo-classical economic instruments have been presented in the society for decades which embraced and promoted by governments. Neo-classical economics have been thought by the politicians as providing less costly policy options, and as easier to implement devices requiring less policing and it is the process of attempting to convert un-priced effects fully into the market. Putting a price on the environment is a band-aid measure and it treats the market as the primary social decision-making mechanism and emphasizes the importance and priority of the economic bottom line. It supposes that once environmental values are internalized business can continue as usual and the environment will be protected. They have been concerned that the public might see taxes or charges as giving companies a “right to pollute” which they had paid for. Similarly, this consideration will cause environmental arguments such as if there is a right to pollute and buy? *(Sharon Beder, 1996)*

Neo-classical economics is frequently criticized for having a normative bias since it does not focus on explaining actual economies. The decision is still attractive to free market advocates, but the balance has been shifted in favor of the environment. So that is this enough to protect the environment for future generations? Whether the price the Neo-classical economist puts on the environment reflects its true value? Whether money payments can correct environmental damage? Such as it is face to new technology problems. As (*Clark N., 1995*) pointed out, the mechanical character of Neo-classical economic models does not allow them to treat evolution or structural changes in the system. This fact led to new approaches as those proposed by

environmental economics. We can find the answers after studying on **Figure 2.1** as below:

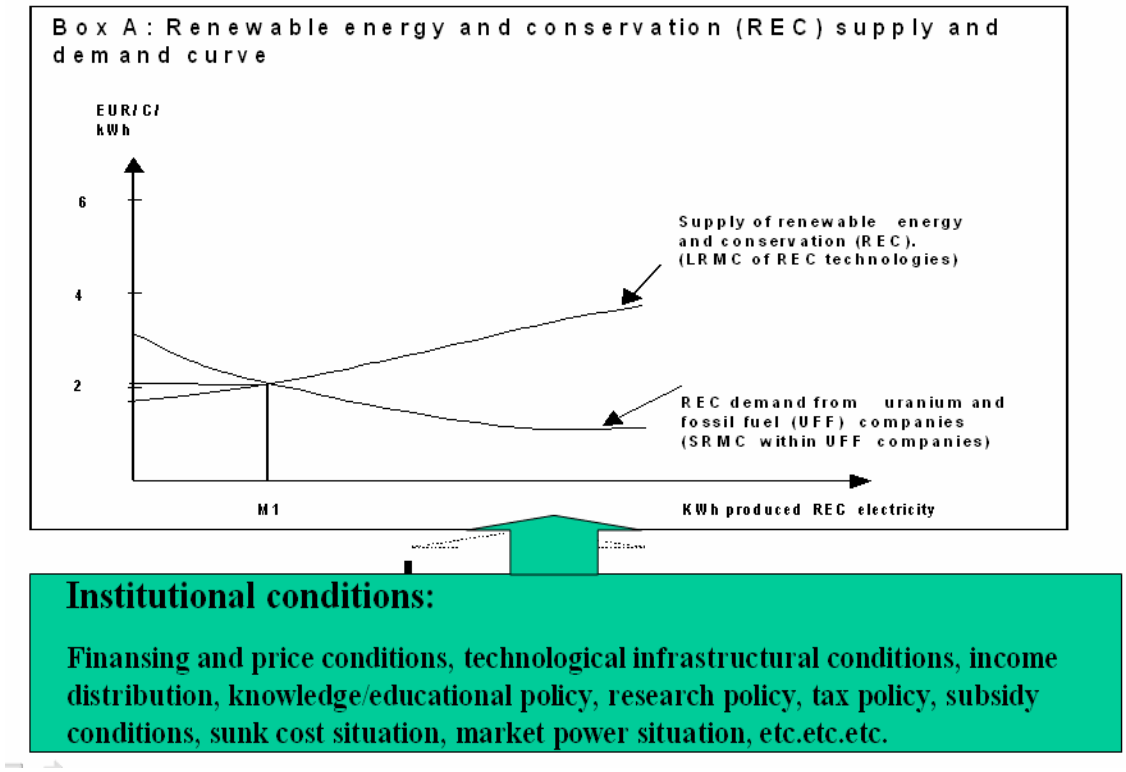

Figure 2.1 Institutional economy and Neo-classical supply and demand thinking. (*Frede Hvelplund, 2003*)

As **Figure 2.1** shown that the research on the renewable energy by (*Frede Hvelplund, 2003*) has proved that with the objective of structural changes with new market curves leading to other optima, it is necessary to change the institutional conditions. Because only these conditions will help the individual increase the marginal benefits or decrease the marginal cost in order to make the optimal point. The Neo-classical economics is not able to explain new demands for technological change since it is an old and market-based theory and it does not willing to *"discuss the institutional conditions determining the where the supply and demand curves are placed." (Frede Hvelplund, 2005)* Furthermore, the prices for the products are not directly present the true value since there are several conditions which you can not price. The money can not correct the environmental damage because it is can be solved by new technology and other institutional conditions.

In order to answer the first research question *"how do the Neo-classical Economics influence the current environmental management policy instruments and what are the limitations of this approach?"* in detail, I am going to illustrate the same environmental instruments that has been mentioned in the above chapter 4: taxes and subsidies, and to find out the limitations and advantages in the following part.

6.1.2 Neo-classical economic instruments

Evaluation of individual instruments is difficult since several instruments are often applied in the pursuit of the same objective. The efficacy of each instrument is therefore complicated and difficult to isolate. The taxes and charges are most often just part of a larger system, where the different parts affect one another. For example, the CO_2 tax is but one tax that confronts households and polluting companies besides energy taxes, other taxes and different regulations in the environmental arena. For another example, the charge such as pesticides does not incorporate the social costs of damage to peoples' health and other activities which arise from their use because these costs are external to the decision maker. And in addition it was report that often the motivation behind the instruments for environmental protection or resource conservation is to avoid the scrutiny of the budgetary process. (*Theodore Panayotou, 1994*)

Taxes and **Charges:**

*Advantages***:**

The Advantage of tax is that it can influence the problem at its source. Neo-classical economists have long advocated an emissions tax levied on each unit of pollution that is discharged, where the tax is set equal to the value of the pollution damages, as a suitable means of equating private and social cost. The tax approach also benefits from these aspects from the Neo-classical economics point of view (*Field, 1994*):

- It is a source of revenue for public authorities.
- Emission taxes produce strong incentives to innovate, to discover cheaper ways of reducing emissions.

Limitations:

The Neo-classical tax system can be a potent device for influencing behavior. In addition to its revenue raising and redistributive functions, the tax system may be used to encourage activities that are socially and environmentally useful and to discourage activities that are not. But in many cases, it has limitation as (*Clive Hamilton, 1999*):

- It may be very difficult to determine an appropriate level of taxes, even when it is only the overall level of pollution that is subject to control, such as in the case of a uniformly mixing pollutant.
- The Taxes and charges are usually kept low because of political pressures from industries not wanting to pay higher charges, and concerns that higher charges might encourage the activities against the charges.
- Charges raise revenue which may be used for environmental purposes but are often merely added to a government's general revenue. “So the Government can get used to this income, and therefore not support innovation activities which decrease pollution and taxes.” *(Frede Hvelplund, 2005)*
- Environmental taxes as a cost-minimizing instrument raise implementation costs. The cost of monitor pollution output is high and there are no highly correlated inputs factors. Polluters and government with bounded rationality will expect opportunistic behavior of each other. “The higher is the asset specificity of the abatement investments, and the more uncertain is the future of the environmental program and its goals, the more difficult it will be to induce efficient investment with the tax approach.” *(Kenneth R. Richards, 2002.)*

Subsides:

*Advantages***:**

- Many subsidies target worthwhile causes, compensating where market or policy failures occur. For example, subsidies can promote competition by helping new companies compete with major players.
- It could assist companies during the transition period and speeding up implementation of new environmental regulations.
- It can be designed to give incentives to enterprises to develop and invest in environmentally friendly technology.

*Limitations***:**

- Although subsidies are selective policy instruments and do by their nature benefit only a few by changing relative prices and resource allocation in the economy, but it can be a burden in a national budgetary context. The burden of economic sacrifice rests on the taxpayer which may not get benefits from this subsides.

- Subsides are not always good for the society. Many subsidies also support activities damaging the environment. Subsidies to industries like timber, mining, and non-renewable energy are detrimental to both the environment and the economy. Subsidies encourage inefficient production by allowing more resources to be used to produce a level of goods and services for which there is no need. Concerning a subsidy given for the use of natural resources, for example, it can encourage misuse and overuse of resources. Well-known examples are oil-exporting countries giving large subsidies for energy use.

- It could encourage indolence of government and pollutants since they do not need to worry about market competition and overuse the undervalued environmental resources such as coal production subsidies.

6.2 Evaluation of Economics of innovation and technological change in environmental sector

For many environmental problems, technological innovations can offer fundamental solutions. The industrial and technological infrastructure that did lead to significant externalities can be transformed to limit detrimental environmental impacts. This transformation process is already happening very smoothly since environmental considerations started to influence all engineering and industrial designing phases. Much progress has achieved of innovation and technical change and yet much remains to be done in environmental sector. However, in addition to progress within the study of technical change it is important today to understand how this can fit together with the Neo-classical economics.

Advantages:

- Promoting the new technological development and innovations.
- Playing a substantial part in environmental management.
- Encourage competition wherever possible in environmental sector

Limitations:

It is still a new theory It is only after World War II and the phenomenal increase in the expenditures on R&D that took place in most industrialized countries that economists started to study systematically innovation and technical change. Therefore it can not be well accepted as the mainstream economics to the public.

6.3 Why do neo-classical policy tools like pollution taxes not sufficiently support innovation?

In the economic literature, many studies on the different effects of environmental policy instruments are concluded that taxes should be preferred to quantity controls when expected marginal benefits were relatively flat. The relative curvature of the cost and damage functions is only part of the reason for preferring taxes. In all these ways, putting a price on the environment is a way of ensuring that the cost of environmental damage is considered by governments, companies and individual consumers when they make their decisions. They said by the Neo-classical thinking, the costs of production for each good or service will be minimized and goods and services will be produced in the most efficient way and in a mix that maximizes consumer's utility or benefit. The payments made by firms in the form of charges can be used to correct the environmental damage they cause. But in fact, For example, a number of studies have shown that 25% to 30% of dischargers do not understand the pricing system and since they do not have sufficient knowledge, they do know how to select methods and costs to make optimal decisions in their own interest. (*Jacobs, 1993*) gives the following example to prove how current policy system helps perople to ignore the technological change. In Britain a rise of 400% in sewerage charges failed to change companies' behavior, even though it was shown that small investments in pollution control would pay back in under a year. The charging system was not understood by the companies affected; it was dealt with by the finance department, not the engineers; and the companies did not know the technological options available. A regulation requiring them to install the better technology would almost certainly have been more efficient--that is, cost less overall--than the huge price hike which would have been required to get the same changes made.

Several years ago, when many companies which sold their products which cause environmental damage, neither they nor the customers pay for that. It means that they are allowed to pollute the earth without paying for the damage. Other companies dig up resources and cut down trees without paying for the loss of environmental assets. Each individual considers only its own profits and costs. Environmental costs seldom get a look in. They are external to the company accounts. Economists call these costs "externalities". So how can the government ask those environmental privates to

consider the environmental impact of their activities? The Environmental economists within the Neo-classical thinking response for this problem is to establish property rights over environmental assets and allow market to operate and to make the market work better by putting a price on the environment. In this way the cost of the pollution is incorporated into the price of its products. The Neo-classical economists have such assumptions as perfect competition, private maximize profits, laws, no public goods and no externalities and so on. One thing we need to pay attention to is if any of these assumptions fail, and then the market equilibrium maximizes privates' benefits, but not society's benefits. And also environment belongings are public goods, and have both positive and negative externalities. Because ownership of environment cannot be established, they cannot be traded on an unlimited market. Hence, unlimited market activities affect the environment far more than is socially desirable. (*Mikeal Skou Andersen, 1997*)

Neo-classical economists also claimed that it is need to be care of investing in technological changes because it is an activity with many so-called business risks. For example, (Scherer and Ross 1990) present the empirical results of the investigations by Mansfield's model[4]. For the firms in the analysis, the average probabilities were:

Technical success (r1)	0.57
Commercialization, given technical success (r2)	0.65
Financial success, given commercialization (r3)	0.74

According to this analysis, they said that the choice of the used environmental policy instrument has a strong impact on a financial success but not on the technical success because of $0.74 > 0.57$.

Therefore in order to make a successful policy instruments, it might be possible to integrate technical success and financial success within one system. Next chapter, I am going to discuss the policy tendencies and prospects for this integration.

[4] Mansfield identify three different success probabilities : (1) the probability that technological goals would be achieved ; (2) the probability that, conditional upon technical success, the resulting product or process would be commercialized ; and (3) given commercialization, the probability that the project yielded a return on investment at least as high as the opportunity cost of the firms capital

6.4 Policy tendencies and prospects

Traditionally, governments have tended to implement environmental policies through direct bureaucratic regulations, couple with system of monitoring and sanctioning of non-compliance (command-and- control). At the same time, the policy objectives should consisted of efficiencies, equity information and monitoring and enforcement costs, and technological incentives. They should give companies incentives to develop and apply new and cleaner technologies in order to avoid tax payments. This can be achieved by the companies if new technology both reduces abatement costs as well as taxes.

There is a fundamental distinction between the use of the market as a tool to help achieve society's goals, and as a blueprint for society's goals. The market is a reasonable policy tool but not a reasonable blueprint. The market as blueprint[5] fails because there are significant public purposes that cannot be achieved by prices and markets alone. Under the market-based policies, polluters are not told what to do; rather, they find it expensive to continue in their old practices and they have a choice about how and whether they change those practices. The innovation and technological economics challenged neo-classical economics. It appeared that the free market economic system was unable to provide economic growth and environmental protection. The government and company should develop different systems to promote energy efficiency and production of renewable energy. The benefits to using technological change that arise from the environment can be substituted for other benefits that can be bought on the market. The idea is that some companies can reduce their pollution more cheaply than others and that it is more efficient to expect them to reduce their pollution more than those companies for whom it would be expensive. There are, for example, investment grants for electricity production based on renewable energy sources. To this can be added production subsidies in the form of tax reductions or direct subsidies. There are also grants for development of cleaner technologies. (*Frank Ackerman, 2000*)

[5] The Market Blueprint is a roadmap with a variety of approaches to estimating market demand, analyzing buyer behavior, exploring competitors' strengths and weaknesses, and evaluating new product ideas.

Therefore the answer to the second research question "*Is it possible that a combination of Neo-classical and the Economics of innovation and technological change can transgress these limitations?*" is:
From the policy tendencies point of view, it is possible to combine them since there are existing incentives and environmental effectiveness.

Inn the next chapter, I will describe the Synthesis of Neo-classical and Innovation and Technological Change Economics incorporate with the increasing interest in economic instruments shown in the current decade may be attributed to a number of policy trends:

1. Economic stagnation and reduced government budgets have induced an interest in more cost-effective approaches. At the same time, direct bureaucratic regulation of societal process seemed to have reached its efficiency frontier, which called for regulatory reform. (It will give a example of tax reform in the coming **Chapter 7.1**)
2. Towards policy integration occurs, within the environmental policy field as well as between traditionally separated policy fields. (It will give a example of integration in the R&D section in the coming **Chapter 7.2**)
3. A gradual transition from curative to preventive environmental policies is to be expected in some environmental fields. (It will give a example of innovative markets in the coming **Chapter 7.3**)

Chapter 7 Synthesis of Neo-classical and Innovation and Technological Change Economics

In this chapter, the discussion of related question followed by suggestions for three examples (Tax reform, D&D and innovative market) will be carried out in order to create a clear picture of the approach of integrate Neo-classical and Innovation and Technological Change Economics instruments. Enriched by the idea of market based mechanism with the advantage of technological change, the integrated policy system will be a specific tool to improve the economic development as well as environmental protection.

7.1 Taxes reform

Current Neo-classical economic instruments are not cost-effective because they require discharges from all companies to meet uniform standards and without consider their faculty to meet them, or they require all companies to implement particular pollution control technologies without consider their faculty to pay for them. It will be a comparatively high cost for several companies. Therefore Neo-classical economic instruments were said to permit “the burden of pollution control” to be shared more efficiently among businesses. (*Sharon Beder, 2001*) But cost-effectiveness can be achieved at which the tax rate or permit price equals the marginal cost of abatement; at the same time, they will also have identical incentives to pursue abatement efforts. However, the incentive or market based instrument is proved not only depend on cost-effectiveness, but also for their capacity to activate technological change and innovation. (*Jaffe and Stavins, 1995*)

Innovation-based evolutionary economic theories have been developing rapidly, as consequence it cause tax reform in recent years. Tax reform is not “*a precise set of proposals but a suite of potential revenue and spending reforms aimed at improving environmental performance without generating economic costs*”. An appropriately designed tax reform package may actually increase economic growth and employment by overcoming some distortions in the economy. It would save government expenditures on environmental regulation and pollution abatement and, in the long

run, increase the tax base and hence tax revenues without increasing the tax burden. *(Clive Hamilton, 1999)*

The idea of integration is to help some companies reduce their pollution more cheaply than others, and that it is more efficient to expect them to reduce their pollution more than those companies for whom it would be expensive. In this way the marginal costs of pollution control, that is the additional cost of achieving an extra unit of pollution reduction, would be equalized between the businesses. For example, each company have pay an equal rate with an effluent charge, but those companies that found it cheaper to use new technology to reduce their pollution than pay the charge would do so whilst those for whom pollution reduction cost more than the charge would pay the charge.

So the suggestions for tax reform of this report are:

1. Taxation should aware of the limitation and continue to deliberate on ways to fix the tax system and to improve the structure of taxes in terms of makes environmental taxes worth considering and more efficiency. For example, reduce or no tax to the renewable energy section and increase the coal-use tax.
2. Taxes reform should provide continuous incentives for allocating efforts and financial investments in innovative activities, with the aim to develop and deploy abatement technologies in order to avoid taxes or permit costs. For example, it is of course required that pollutants respond to price, and that the price incentives should be sufficiently high so as to stimulate investments in new technologies or behavioral change.
3. Tax reform should reduce conventional Neo-classical taxes and replace them with innovation taxes, introduce or specify technologies that facilities can adopt. Taxes reform would allow them to choose alternative controls that better fit the attributes of their facility and the wastes management. So as to leave the total tax burden unchanged, would bring the economy closer to sustainable development by stimulating economic growth and resource conservation and discouraging resource depletion and environmental pollution.

7.2 Integration of Neo-classical subsides with the R& D section.

The basic idea of a Neo-classical subsidy, as well as taxes, is to change the price structure to the advantage of certain products or technologies. Environmental taxes and subsides are the instruments with only price implications, offer less certainty on the effective reduction of emissions than quantity instruments like tradable emission rights. It is argued that subsidies can be considered a negative tax since there are certain kinds of subsidies existed, such as direct price support for fossil fuels. But there are also some subsidies are likely to stimulate innovation in the sense of being perceived which is in some cases with taxes or fees or the effects of adoption subsidies on technology diffusion appear to be substantially greater than expected. For instance, R&D activities with publicly funded commonly reveal an important factor in the process of technological change and innovations that may lead to niche market application, commercialization and pervasive market diffusion. And also the instrument which fundamentally oriented will generate good opportunities and freely available market of knowledge. In terms of if taxes turn out to be very expensive for the pollution or emitting industries, the companies would be more interested to invest in new technologies than the high-paid policy instrument, since the new technologies will lead to a very limited cost and reduce the cost by a long-term run. Therefore it is necessary to develop a dynamic model that enables to compare the incentives on environmental R&D resulting from taxes, emission trading, voluntary approaches and subsidizing environmental R&D.

Why will the companies integrate R&D with Neo-classical Economics?

The reason why can be explained by the following **Figure 7.1.**

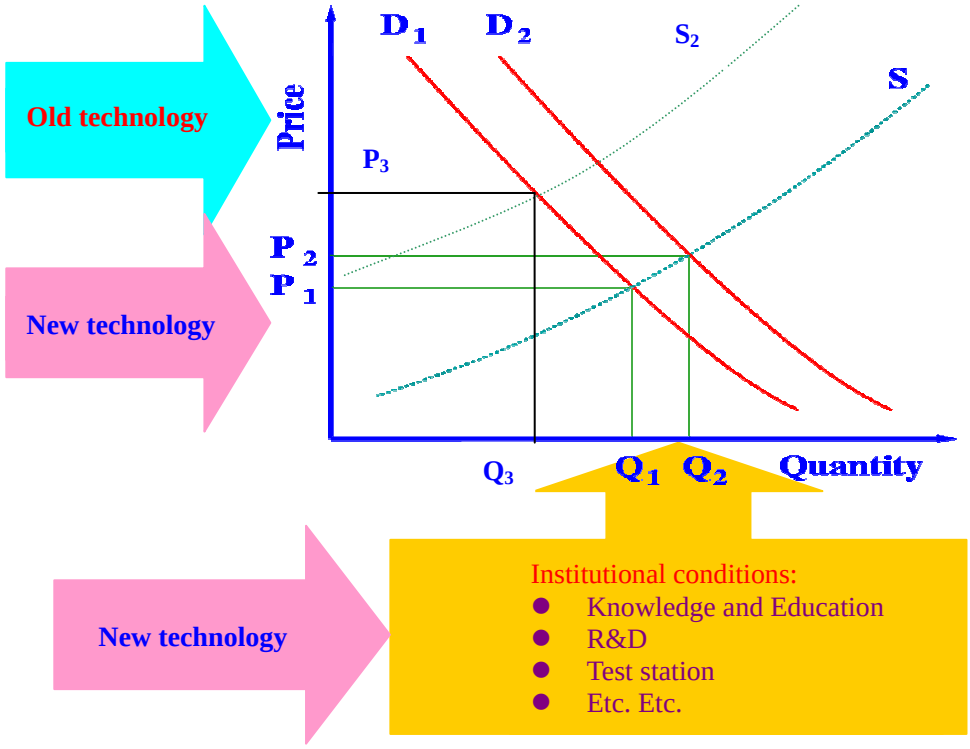

Figure 7.1 Supply and demand model (*Frede Hvelplund, 2005*)

This supply and demand model describes how prices vary as a result of a balance between product supply and demand. The Figure depicts a decrease in demand from along with increase in price and the consequent is to reach a new equilibrium point on the supply curve. Curve D_1 and S_2 represent the demand and supply of introducing old technology policy system such as coal. The optimal solution point for the equilibrium reflects price P_3 and quantity Q_3. But after introducing new technology, we could find out the demand curve is changed to D2 and the optimal solution point for the equilibrium reflects P_2 and Q_2. It means that the price has been decreased and the quantity has been increased. The reason why it has such kind change is there are several institutional conditions behind the changes, such as the price was decrease because R&D reduced the cost, so that the demand increased. Therefore, companies in order to achieve the right equilibrium, they have to think about combine the new technology with the market equilibrium. By means of this figure, it is possible to say

that the synthesis should include a combination of the neo-classical regulation system and the innovation economy regulation system. It contains not only promotion of the old system developing with R&D, but also stimulates innovation of technologies.

There is a great demand for R&D in current world, for example, study shows between 1997 and 2002, Chinese national and local governmental spending on research were approximately US$9.9 billion. From 1996 to 2002, the ratio spending on R&D in China as a percentage of GDP has grown from 0.6%to 1.29%. (*Dennis Normile, 2005*)

There is another good example from the report that University of Ghent has been investigated on the Government subsidizing R&D of environmental technologies. They tested five levels of the subsidy; from 0 to $500000, each step increasing by $100000. They found that the value for "R&D Incentive[6]" increased to 14.01 when the subsidy is $500000. When the subsidy was $400000, R&D Incentive amounted to 11.08 and with a subsidy of $100000 the calculated value was 8.5. Compared to this case, it is possible to conclude that subsidizing environmental R&D has a more interesting impact on the incentive to invest in new technologies. (*Johan Albrecht, 2003)*

The suggestions for integration subside and R&D is:

- The ration of subsides should tend to R&D program, because R&D can improve the economic performance and thus make immature technologies more competitive.
- The strategic company decision-making on the environmental management should involve future developments and financial supporting to the R&D program and the integrated governmental policy would provide a very strong incentive for the companies that will receive these subsidies by R&D.

[6] R&D Incentive = (profits from innovation - cost of the innovation)/ cost of the innovation,

7.3 An example of integration -- Innovative markets

The goal of Innovative Market Mechanisms is to demonstrate innovative market-based strategies to promote widespread use of new technologies due to the increasing market demands and the quoted increasing competition in many places. It can be a good example to interpreter the combination of Neo-classical economics and Innovation and Technological Change among the developed and developing counties. In this section, it will illustrate the innovation market of photovoltaic energy in Germany and China.

Actually Innovative Market has such activities as below: (*Biomass Electricity future RTD Needs, 2005*)

- Smaller consumers such as small businesses,
- A valuable way of exchanging information and new technology..
- Demonstration or dissemination of market development activities.

Germany is the world's fifth largest energy consumer and its primary energy consumption in 2003 was 14451 PJ. Photovoltaic energy contributes 333Gwh which occupied 17.8% of the electricity generation. The reason behind this successful improvement is Germany has well established a policy instrument system to promoting the renewable energies such as the Innovative Market. See **Figure 7.3**. (*Danyel Reiche, 2005*)

Source	Capacity	Tariff (cEuro/kWh)	Period/year
Photovoltaic energy	On the top of or on buildings or on noise protection walls	57.40(up to 30kW) 54.60(up to 100kW) 54.00(From 100kW)	20
	Plants intergrated in Buildings	62.40(up to 150kW) 59.60(150 to 500kW) 59.00(500 to 5000kW)	20
	Other	45.70	20

Figure 7.3 Feed-in tariffs for Photovoltaic energy in Germany, 2004

Figure 7.1 shows that the price for the Photovoltaic energy in Germany was above 45 cEuro/kWh. But it was report that the average price of electricity in Germany was almost 5.39 cEuro/kWh. It is means that with the central financial support programme for the renewable energy, the new technology has been well promoted by the innovation market mechanisms. It is an example of carry out tax reform which I have mentioned in the last section. It is testify that Innovation and Technological change can be promoted by combine with the market-based instrument. (*National Energy Policy Overview, 2005)*

China did encourage the development of renewable energy applications as well. The government has introduced incentives and instruments including subsidies, tax breaks and access to credit and so on. These policies have promoted the use of Photovoltaic energy over the last 10 years. And the market has increased about 20% every year. From 1981 to 2001, more than 3.5 MkW of solar power were being generated by nearly 25,000 Photovoltaic energy systems throughout China. At the end of 1993, 3.3 MW of solar cells were in use in China. China plans to use photovoltaic mainly in remote mountainous districts and islands along the coasts, where electricity for households is not available. It can be shown in **Figure 7,4**

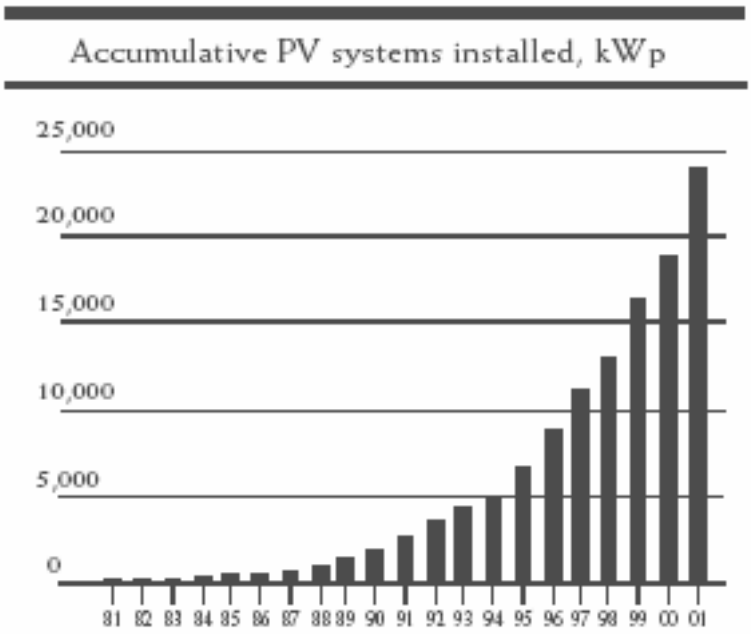

Figure 7.4 Photovoltaic energy systems installed in China, 1981–2001 (*Yuwen Zhao, 2002*)

Chinese government also used the Innovative Market Mechanisms to protect the usage of Photovoltaic energy. According (*the National Law of Renewable Energy, 2005*), the price of photovoltaic energy can be as 3 time higher than the normal coal electricity.

7.4 The ideology possibility for accept the integration instrument

The use of Innovation and Technological Change has been introduced escalating during the recent years. But the way combine the thinking of Neo-classical economics with the Economics of innovation and technological change in order to gain the support from each other might be sort of new for this society, so I think it is important to discuss the acceptable of this integration in different aspects.

Industry and Business

The environmental problem for many companies and businesses has been treating as increasing governmental constraints on their activities. Price-based instruments were looked as additional costs which they would prefer to avoid. A charge is the financial burden as well as legislative instruments and is a primary reason why carbon taxes have been opposed by business groups in various parts of the world. It is necessary to built flexibility of economic instruments which could give companies a choice and allow them to make their own decisions. Economic instruments should provide both an alternative to restrictive legislation and the sight that are not obviously self-interested. So I think it is possible to introduce the integration system to them.

Bureaucrats and Politicians

The ongoing environmental market-based instrument system is transforming environmental conflicts from political problems to economic transactions since politicians have been attracted to the idea of economic instruments by the economists' promise that they will remove decision-making from the public arena thereby depoliticizing environmental debates. Environmental controversy can be politically damaging and can interfere with the bureaucratic decision-making process.

Politicians have to face this environmental problem as a potential politically damaging conflict. In making policy decisions in this area they are forced to make choices which could solve the problem. Bureaucrats also want to see this problem more of a technical problem so that can be solved more efficiently without political interference. Both politicians and bureaucrats have reason to pick up a solution that is technocratic

and non-political and this is the way economists have sold economic instruments. So I think it is possible to introduce the integration system to them.

Environmentalists

Environmentalists are perhaps the most excited person for converts a market-based approach to an integrated policy instruments. When Neo-classical economists speak of valuing the environment they mean giving it a market price based on supply and demand but the environmentalists prefer to make technological change instead of solve the problem by using a mathematics way. Environmentalists have willingly accepted that all the possible instruments at our disposal should be considered on their merits in achieving our policy objectives, without either ideological or Neo-classically-inspired theoretical judgments. In fact the ideological and political shaping of these instruments has been hidden behind a mask of neutrality.

Market-based measures grant the highest decision-making power over environmental quality to those who currently make production decisions now. A market system gives power to those most able to pay. Corporations and companies rather than citizens or environmentalists will have the choice about whether to pollute (and pay the charges) or clean up. Economic instruments are being advocated as a technocratic solution to environmental problems which is premised on the economist's view of the problem. So I think it is possible to introduce the integration system to them.

Chapter 8 Conclusions

Refer to the research question *"How do the Neo-classical Economics influence the current environmental management policy instruments and what are the limitations of this approach? Is it possible that a combination of Neo-classical and the Economics of innovation and technological change can transgress these limitations?"*, this report have discussed the related issues. It concludes that the investigation of this report has shown that the perception that the environmental policy, which is very much in connection with the advice of neo-classical economics, is limited. It is indispensable that the request of developing Innovation and Technological Change instruments has to be considered in order to extend the usage of policy instrument. Although innovation is incompatible with neo-classical competitive equilibrium, the incorporation of ideas is an essential ingredient for sustainable economic systems.

Q1. How the Neo-classical Economics influence the current policy instruments and what are the limitations of this approach?

This research question has been answered in **Chapter 5**. As we known, market-based policies like Neo-classical instruments have made an undeniable contribution to environmental protection. The contribution for the current policy instruments is extremely big and influential. But the benefits of price-based instruments are far more theoretical than real.

It has such limitations are listing as below:

- As it has been discussed, we are aware of the existing Neo-classical environmental instruments has limited the development of new effective environmental technologies. For example the use of charges has not been shown to provide incentives for innovation and pollution reduction measures.
- There are many unpriced or under-priced effects (such as environmental resources and spillover effects of human production and consumption activity). Neo-classical theory has the shortages to face these effects since it is a price-based policy and it is not able to explain these effects by its own policy system..

- From **Figure 2.1** we know that institutional and technological conditions influence the operation of the market but the neo-classical economics attempt to keep stability and try to manage the market dominated by the price. The Neo-classical economists only focus on the price-based instrument and neglect the institutional conditions which are behind the curve. Within the existing Neo-classical policy instruments, the innovation and technological change will be block at certain level.

Q2. Is it possible that a combination of Neo-classical and the Economics of innovation and technological change can counteract these limitations**?**

Chapter 7 was to answer this research question by giving the three examples. The three examples give you an idea about the integration system and the consequence which is the answer to the questions is to combine these two economics and built a integrated economic instruments. This flexible economic instruments will suit the environmental concerns better. It is possible to integrate Neo-classical and the Economics of innovation and technological change can counteract these limitations.

- The policy instrument can be designed to be revenue-neutral for the government; for example revenues can be recycled to support specific environmental objectives such as investment in cleaner technologies, or to reward better performers. Taxes reform should provide continuous incentives for allocating efforts and financial investments in innovative activities, with the aim to develop and deploy abatement technologies in order to avoid taxes or permit costs.
- The current policy instruments have not usually told companies what technology to use, emissions standards have been set on the basis of existing technologies, and what could reasonably have been achieved rather than on the basis of environmental goals which could have provided an incentive for technological change over time. So the strategic company decision-making on the environmental management should involve future developments and financial supporting to the R&D program and the integrated governmental policy would provide a very strong incentive for the companies that will receive these subsidies by R&D

- Neo-classical economics is just one economic approach for dealing with environmental problems, while the Economics of innovation and technological change is just playing an unimportant role in the existing policy system since it is still a new approach. So if combine them together within an innovative market, it will achieve the environmental goal on both side.

In addition, the behavior of waiting for new technologies to arrive would be unacceptable and even too risky. Therefore environmental policy should design instruments that can promote a behavior that enables it to internalize external effects.

Furthermore, as appendix 2 shown, this report also lists some suggestions which in a table for the use of environmental policy instruments in different technological and economic context. This table describes the effectiveness and efficiency characteristics of different policy instruments.

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Appendix 1

TAX	1990	1991	1992	1993
DENMARK				
Duty on petrol	1.45	1.36	1.36	1.29
Motor vehicle registration duty	2.03	2.07	2.02	1.91
Sales on vehicle number plates	0.07	0.07	0.07	0.06
Duty on electricity	1.11	1.10	0.95	0.81
Duty on certain oil products	0.81	0.93	0.97	1.09
Duty on certain retail containers	0.10	0.11	0.11	0.08
Duty on gas	0.01	0.01	0.01	0.01
Duty on extraction/import of raw materials	0.03	0.03	0.03	0.03
Duty on disposable tableware	0.02	0.02	0.01	0.01
Duty on insecticides in small containers	0.00	0.00	0.00	0.00
Duty on coal	0.22	0.22	0.18	0.17
Duty on waste	0.10	0.12	0.11	0.12
Duty on CFC	0.01	0.00	0.00	0.00
Duty on CO2	–	–	0.36	0.76
Weight duty on autos paid by households	0.71	0.82	0.73	0.70
Weight duty on autos paid by others	0.41	0.30	0.27	0.26
TOTAL	**7.08**	**7.16**	**7.19**	**7.30**
NORWAY				
Excise on petrol	2.31	2.47	2.86	2.78
Vehicles transfer tax	1.49	1.28	1.54	1.54
Electric energy	1.12	1.05	1.06	1.12
Oil and gas products	2.87	2.96	2.64	2.52
Mineral oil	0.36	0.64	0.61	0.52
CO2 tax	–	0.25	0.59	0.68
Motor vehicles tax paid by households	0.58	0.67	0.79	0.83
Motor vehicles tax paid by others	0.68	0.69	0.77	0.76
TOTAL	**9.40**	**9.99**	**10.86**	**10.75**

Environmental taxes (as a percent of total tax revenue) in Denmark and Norway (*OECD, 1995)*

Appendix 2